2 INSTRUMENTATION

The types of instruments commonly used in field radiological surveys are briefly described in this section. The instrumentation that was used in this study is specified by make and model. This was necessary in the event that the data generated in this study are reviewed and/or compared to the results obtained by other investigators. However, the use of these instruments does not, in any way, represent an endorsement of a particular product, or a particular manufacturer, on the part of ORISE or the NRC.

2.1 Gas Proportional Detectors

Gas proportional detectors are used for detecting both alpha and beta radiation. Ludlum 43-68 detectors, with a physical probe area of 126 cm^2 (effective probe area is 100 cm^2, which accounts for the fraction of the probe area covered by the protective screen), were used in this study. Gas proportional detectors with larger probe surfaces, such as the Ludlum Model 43-37 detectors with a physical probe area of 573 cm^2, are suitable for scanning surface areas. The detector cavity in these instruments is filled with P-10 gas (90% argon, 10% methane). Alpha or beta particles, or both, enter this cavity through an aluminized Mylar window. The density thickness of this window is one factor that can affect the detector efficiency, hence the MDC of the instrument. The instrument can be used to detect (a) only alpha radiation by using a low operating voltage, (b) alpha and beta radiation by using a higher operating voltage, or (c) only beta radiation by using a Mylar shield to block the alpha particles in a mixed alpha/beta field. Instrument response was evaluated using all three modes of operation.

2.2 Geiger-Mueller Detectors

"Pancake" detectors are used for detecting beta and gamma radiation (these detectors can also respond to alpha radiation to varying degrees). Eberline Model HP-260 detectors were used in this study. This instrument has a physical probe area of approximately 20 cm^2 (15.5-cm^2 effective probe area). The detector tube is filled with readily ionizable inert gas, which is a mixture of argon, helium, neon, and a halogen-quenching gas. Incident radiation enters this cavity through a mica window. The density thickness of the window can vary between 1.4 and 2.0 mg/cm^2, affecting detection sensitivity. The output pulses are registered on a digital scaler/ratemeter with a set threshold value.

2.3 Zinc Sulfide Scintillation Detectors

Alpha scintillation detectors use scintillators as detection media, instead of gas. A commonly used detector is the zinc sulfide scintillation detector, which uses silver-activated zinc sulfide, ZnS(Ag). The Eberline Model AC-3-7, with a physical probe area of 74 cm^2 (59 cm^2 effective probe area), was used in this study. Alpha particles enter the scintillator through an aluminized Mylar window. The Mylar window prevents ambient light from activating the photomultiplier, but is still thin enough to allow penetration by alpha radiation without significant energy degradation. The light pulses are amplified by a photomultiplier, converted to voltage pulses, and counted on a digital scaler/ratemeter with a set threshold value.

2.4 Sodium Iodide Scintillation Detectors

For detection of gamma radiation, thallium-activated sodium iodide scintillation detectors are widely used. Primarily, these detectors are useful for scanning surface areas for elevated gamma radiation. In this study, the Victoreen Model 489-55 with a 3.2-cm × 3.8-cm (1.25" × 1.5") NaI(Tl) crystal and the Ludlum model 44-10 with a 5.1-cm × 5.1-cm (2" × 2") NaI(Tl) crystal were used. The output voltage pulse is recorded on a ratemeter.

2.5 Ratemeter-Scalers

The detectors that were described above are used in conjunction with ratemeter-scalers. The detector response is recorded as an integrated count or it is noted as a count rate, or both. Both modes of operation were evaluated in the study. The following instrument combinations were used: Ludlum Model 2221 ratemeter-scaler was used with Ludlum 43-68, Eberline HP-260, and Eberline AC-3-7 detectors; and Ludlum Model 12 ratemeter-scaler was used with the Victoreen 489-55 and Ludlum 44-10 detectors.

2.6 Pressurized Ionization Chamber

The pressurized ionization chamber (PIC) can be used to monitor "real time" direct gamma-ray levels and record exposure rates. Ionization chambers operate by collecting ions within a cavity chamber filled with pressurized argon gas. The current generated is proportional to the amount of ionization produced in the chamber. Quantitative measurements of exposure rate are made and recorded in microroentgen per hour. In this study, Reuter-Stokes Model RSS-112 was used.

2.7 Portable Gamma Spectrometer

Portable gamma spectrometers can be used to identify and quantitate gamma-emitting radionuclides in the field. The Environmental Survey and Site Assessment Program (ESSAP) at ORISE has used the portable gamma-spectrometry capability, mainly for qualitative analysis of contaminants in the field, but not to obtain data for direct comparison with the guidelines. The system used by ESSAP for this study was manufactured by EG&G ORTEC, and includes a 13% relative efficiency, p-type germanium detector.

2.8 Laboratory Instrumentation

The study of field survey instruments was extended to include a limited number of measurements using laboratory instrumentation. The following laboratory instrumentation was used:

- Canberra 3100 VAX workstation connected to intrinsic germanium detectors (Oxford instruments and EG&G ORTEC) with extended range capability for low-energy x-rays

- Canberra 3100 VAX workstation connected to solid-state alpha detectors (Canberra and Oxford instruments)

- low background alpha/beta gas flow proportional counters (Oxford instruments)
- liquid scintillation counter (Packard instruments)

2.9 Additional Instrumentation

Additional survey instrumentation commonly used for decommissioning surveys that were not evaluated in this report, includes in part:

- The FIDLER (Field Instrument for the Detection of Low Energy Radiation)—consists of a thin NaI crystal and used to detect gamma and x-radiation below 100 keV.
- The dual phosphor alpha and beta detector—consists of ZnS(Ag) adhered to a plastic scintillation material. This detector allows for the simultaneous assessment of alpha and beta radiation at each survey location. Cross talk between the alpha and beta channels should be carefully considered when evaluating the data.

Other instrumentation of emerging importance, but not studied in this report includes, in part:

- devices that track both the position and output of radiation detectors, such as the ultrasonic ranging and data system (USRADS). USRADS (from ChemRad) provides a documented survey by correlating the location and magnitude of the instrument response at one-second intervals. Similarly, the Thermo Nutech laser assisted ranging and data system (LARADS) combines radiological data acquisition and spatial identification in to produce a documented radiological survey. Both systems eliminate subjective interpretation of the data by the surveyor and provide verification of the survey are coverage.
- a floor monitor developed by Shonka Research Associates, Inc. that uses position sensitive proportional counter-based radiation detectors. The position-sensitive proportional counter allows one detector to act as the equivalent of hundreds of individual detectors—which results in the collection of vast amounts of data. Process software saves the survey data at very high rates and correlates the data as a function of survey location. The system provides completely documented radiation surveys and allows visualization of the survey results in a real-time mode.